Machine Learning for Author disambiguation

Gilles Louppe

CERN

March 2, 2015

Motivation

For each author, group together all his publications, and only those.

M.S.Smith.1

Name Variants

Smith, Miles (3)
Smith, Matthew W.L. (6)
Smith, Matthew W. L. (5)
Smith, Matthew (19)
Smith, Mat (5)
Smith, Martin C. (15)
Smith, Martin (1)
Smith, Mark (3)
Smith, Marcie (1)
Smith, M. S. (1)
Smith, M.W.L. (66)
Smith, M.W.E. (78)
Smith, M.W. (10)
Smith, M.S. (65)
Smith, M.R. (6)
Smith, M.L. (5)
Smith, M.K. (14)
Smith, M.J.T. (1)
Smith, M.J.S. (22)
Smith, M.J. (44)
Smith, M.H. (1)
Smith, M.F. (2)
Smith, M.E. (2)
Smith, M.D. (2)
Smith, M.C. (34)

No more

Z.Liang.4

Name Variants

Liang, Zhijun (1)

Z.Liang.5

Name Variants

Liang, Zhijun (1)

...

Z.Liang.83

Name Variants

Liang, Zhijun (1)

No less

S.W.Hawking.1

Name Variants

Hawking, Stephen W. (11)
Hawking, Stephen (18)
Hawking, S.W. (177)
Hawking, S. W. (1)
Hawking, S. (14)

But all and only the correct ones

$$\{s_1, s_2, \ldots, s_N\}$$

Author disambiguation

$$\{\underbrace{\{s_1, s_3, s_4\}}_{\text{author 1}}, \underbrace{\{s_2, s_5\}}_{\text{author 2}}, \ldots\}$$

Spread of the problem

As extracted from claimed publications in INSPIRE,

- Authors have on average 2.06 name variants (synonyms)
  Eg. : Doe, John ; Doe, J.
- Unique name variants are shared on average by 1.04 authors (homonyms)

Clustering on exact full names or last name + first initial, should yield very good results on average.

But, disambiguation issues are expected to amplify with the rise of Asian researchers : Caucasian names (now representative of INSPIRE authors) are almost never ambiguous, while Asian names are very often.

How would *you* fare ?

A Preon Model With Family Replication From a $D = 6, N = 2$ Supergravity Theory

Hitoshi Nishino, Jogesh C. Pati, S.James Gates, Jr. (Maryland U.)

Dec 1984 - 15 pages

Phys.Lett. B154 (1985) 363
DOI: 10.1016/0370-2693(85)90410-1
MDDP-PP-85-125

Two Loop Finite Temperature Effective Potential Wess-zumino Model

Yasushi Fujimoto (Kyoto U., Yukawa Inst., Kyoto) , Hitoshi Nishino (Maryland U.)

Mar 1985 - 22 pages

Phys.Rev. D32 (1985) 2167
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RIFP-589

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Dec 23, 2013 - 6 pages

Phys.Rev.Lett. 112 (2014) 131302
(2014-04-02)
DOI: 10.1103/PhysRevLett.112.131302
e-Print: arXiv:1312.6645 [astro-ph.CO] | PDF
Experiment: POLARBEAR

Search for proton decays via p ---> e+ pi0 and p ---> mu+ pi0 in Super-Kamiokande

Haruki Nishino (Tokyo U., ICRR)

2008 - 1 pages

J.Phys.Conf.Ser. 136 (2008) 042018
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How would *you* fare ?

Supergravity in $d = 9$ and Its Coupling to Noncompact σ Model

S.J. Gates, Jr. (ICTP, Trieste & Maryland U.) , H. Nishino, E. Sezgin (ICTP, Trieste)

Aug 1984 - 12 pages

Class.Quant.Grav. 3 (1986) 21
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✗ Different authors

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✓ Same authors

Learning from data

- Manual disambiguation is long and difficult, even for experienced curators.

- Couldn't we automatically find a set of rules to disambiguate two signatures ?

$$\varphi(s_1, s_2) = \begin{cases} 0 & \text{if } s_1 \text{ and } s_2 \text{ belong to the same author,} \\ 1 & \text{otherwise.} \end{cases}$$

- This is a machine learning task called supervised learning.

Supervised learning

- The inputs are random variables $X = X_1, ..., X_p$;
- The output is a random variable Y.

- Data comes as a finite learning set

$$\mathcal{L} = \{(\mathbf{x}_i, y_i) | i = 0, \ldots, N-1\},$$

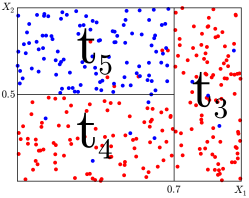
where $\mathbf{x}_i \in \mathcal{X} = \mathcal{X}_1 \times ... \times \mathcal{X}_p$ and $y_i \in \mathcal{Y}$ are randomly drawn from $P_{X,Y}$.

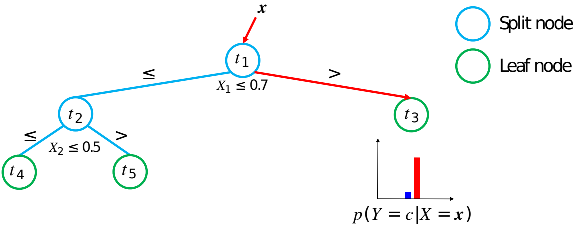
E.g., :
$(\mathbf{x}_i, y_i) = ((\text{name sim.} = 0.7, \text{title sim.} = 0.3, ...), \text{same authors})$
$(\mathbf{x}_j, y_j) = ((\text{name sim.} = 0.1, \text{title sim.} = 0.5, ...), \text{different authors})$

- The goal is to find a model $\varphi_{\mathcal{L}} : \mathcal{X} \mapsto \mathcal{Y}$ minimizing

$$Err(\varphi_{\mathcal{L}}) = \mathbb{E}_{X,Y}\{L(Y, \varphi_{\mathcal{L}}(X))\}.$$

Decision trees [L. Breiman, 1984]

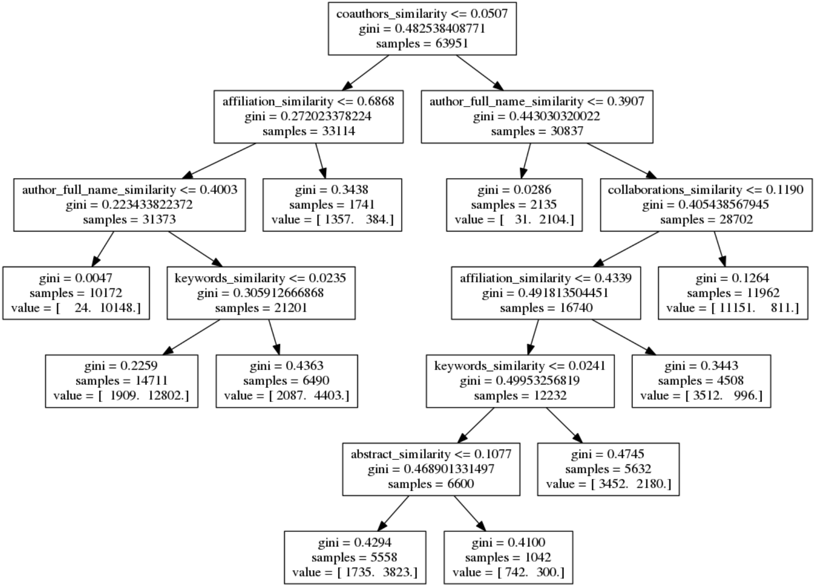




- Heterogeneous data
- Non-parametric model (detect non-linear interactions)
- Easily interpretable
- But prone to overfitting (high variance)

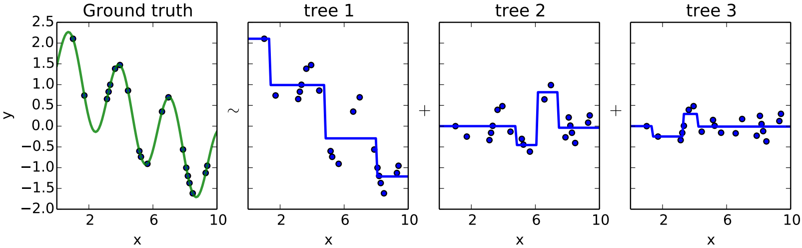
`sklearn.tree.DecisionTreeClassifier|Regressor`

Decision trees



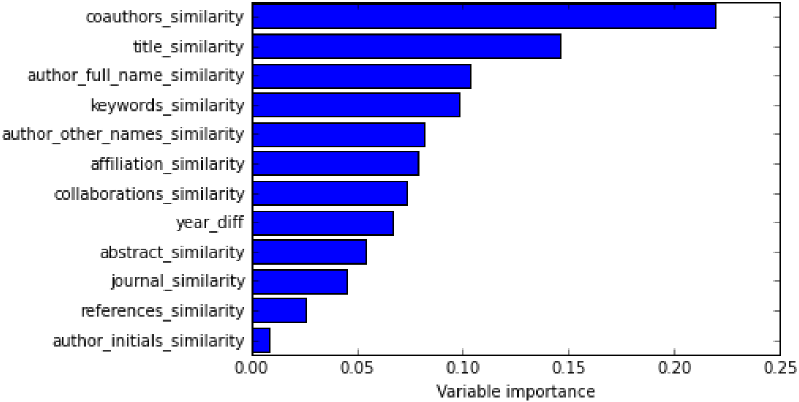
Gradient Boosted Regression Trees [J. Friedman, 1999]

- Ensemble of regression trees approximating the (negative) gradient of a loss function
- Each tree is a successive gradient descent step
- Low bias and low variance

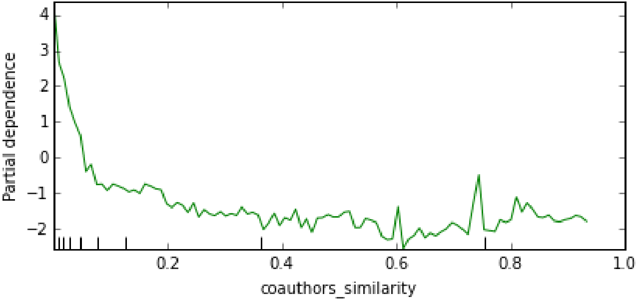


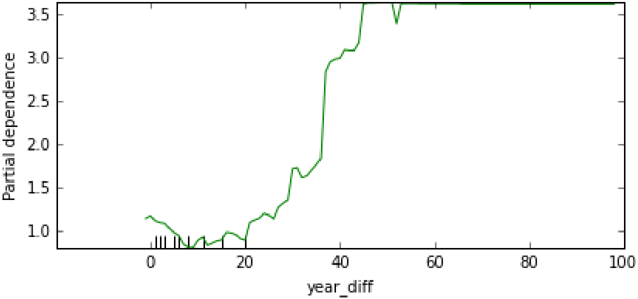
sklearn.ensemble.GradientBoostingClassifier|Regressor

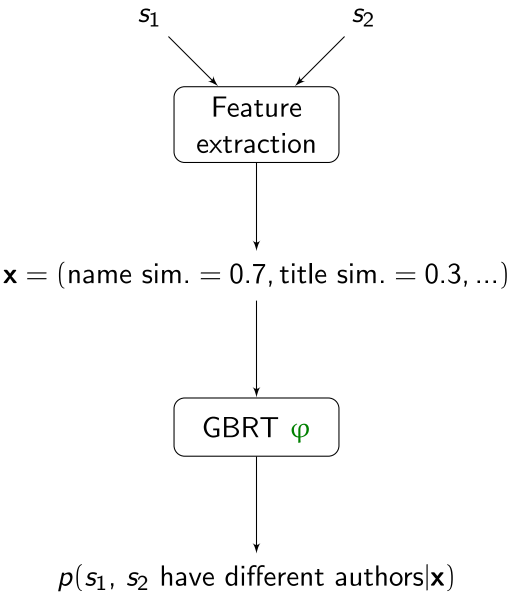
Variable importances



Partial dependence plots

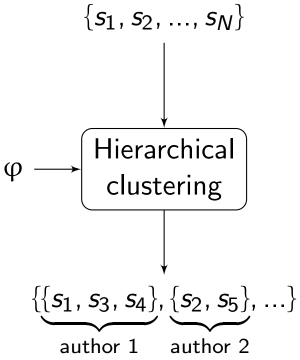




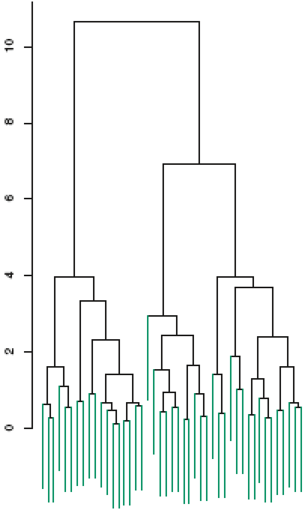

s_1
s_2
Feature extraction
$\mathbf{x} = (\text{name sim.} = 0.7, \text{title sim.} = 0.3, \ldots)$
GBRT φ
$p(s_1,\ s_2 \text{ have different authors} | \mathbf{x})$

Disambiguation as a clustering problem

- Author disambiguation = clustering signatures that belong to the same author.
- Using our model φ, the probability that two signatures belong to different authors can be used as a (pseudo) distance metric.



Hierarchical clustering



- General family of clustering algorithms that build nested clusters by merging them successively.
- This hierarchy of clusters is represented as a tree (or dendrogram).
- The root of the tree is the unique cluster that gathers all the samples, the leaves being the clusters with only one sample.

Issues

- The complexity of hierarchical clustering is $O(N^2)$. For $N = 10^7$ signatures, this is impractical.
  Solution : pre-cluster into blocks all signatures with the same last name + first initial, then cluster each of these blocks.

- How do you set the cut-off threshold ?
  Solution : using training data (e.g., claimed signatures), pick the threshold that locally maximizes some criterion.

Evaluation

Protocol : Use the claimed signatures (about 1M) to form ground truth clusters. Keep 10% as a training set to find model parameters, and 90% as a test set for evaluation.

$$B^3 \text{ Precision} = \mathbb{E}_s\{\frac{|\hat{C}(s) \cap C(s)|}{|\hat{C}(s)|}\} \tag{1}$$

$$B^3 \text{ Recall} = \mathbb{E}_s\{\frac{|\hat{C}(s) \cap C(s)|}{|C(s)|}\} \tag{2}$$

$$B^3 \text{ F-score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}} \tag{3}$$

where $C(s)$ (resp., $\hat{C}(s)$) is the true (resp., predicted) set of signatures to which s belongs.

Results

Method	B^3 *F-score*
Full name	0.8183
Last name + First initial	0.9403
Current prototype	0.9701

On-going improvements

- Better evaluation metrics.
- Better exploitation of the training data (e.g., for setting the thresholds, for pre-initializing known clusters, etc).
- Evaluate alternative input features, supervised learning algorithms and clustering algorithms.
- Limit model complexity to avoid overfitting and speedup the procedure.
- Deployment.